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## THE CLASSIFICATION OF THE UPPER PALÆOZOIC ROCKS OF CENTRAL KANSAS.<sup>1</sup>

[Continued from Vol. III., No. 6.]

### THE NEOSHO FORMATION.

Between the Cottonwood formation and the base of the first massive limestone, containing an abundance of flint in layers, is a series of gray limestones alternating with various colored shales, some of which are yellowish-gray in color, corresponding in lithological appearance, and containing a fauna similar to the Cottonwood shales, while others are olive and reddish in tint and non-fossiliferous. Interstratified are shaly limestones and dark gray hard limestones which contain an abundant Lamelli-branch fauna. Numerous exposures of this formation occur in Chase county along the Cottonwood and its branches, and also to the northeast in the Neosho valley in Morris county. On account of the excellent exposures of this formation in the Neosho valley and its tributaries extending from three miles northwest to six miles southeast of Council Grove it is proposed to call this mass of rocks the *Neosho formation*. In the vicinity of Council Grove there are good exposures in the steep hills near the city and especially along Elm and Four Mile Creeks, which are western branches of the Neosho River south of Council Grove.

*Geologic section of the Neosho formation.*—In Chase county there are good exposures of this formation at the following localities: on "Crusher Quarry Hill," one and one-half miles west of Strong City; on the western side of the Cottonwood River opposite and above Clements; on Buckeye Creek, south of Cottonwood Falls; on Rock Creek, west of Bazaar; and on South Fork of the Cottonwood River, near Matfield Green. The Crusher Quarry Hill affords a good section of this formation; the Cotton-

<sup>1</sup> Published by permission of the Director of the United States Geological Survey.

wood limestone appears at the foot of the hill, near railroad level, while the first heavy stratum of flint and limestone of the so-called "Flint Hills" forms the brow of the bluff. The following section of the exposures on the slope and along the road up to the Crusher Quarry gives quite accurately the thickness of the various strata composing this formation:

		Feet.	Feet.
No. 20.	Soil at top of bluff - - - - -	2	= 168
" 19.	Massive light gray limestone - - - - - containing an abundance of flint. The stratum quarried for the railroad crusher.	19	= 166
" 18.	Yellowish shaly limestone - - - - -	2 ½	= 147
" 17.	Light gray limestone - - - - - with an abundance of flint. The base of the first heavy flint limestone.	1 ½	= 144 ½
" 16.	At top fine yellowish shales - - - - - with Cottonwood shale fauna; the lower shale are coarser.	23	= 143
" 15.	Massive limestone - - - - - in some places 4 feet thick and quarried. Near Council Grove limestone, from 25-30 feet, below the base of the flint, containing <i>Pleuro-</i> <i>phorus</i> , and above the limestone are ferns.	3 ±	= 120
" 14.	Mainly yellowish shales - - - - - some greenish with thin, shaly limestones.	36	= 117
" 13.	At top limestone with <i>Pseudomonotis</i> - - - 2' 10" in thickness; one layer of the limestone contains an abundance of small iron concre- tions. Below are shales.	10 ⅔	= 81
" 12.	Light gray limestone - - - - - containing <i>Pseudomonotis</i> .	1 ⅓	= 70 ⅓
" 11.	Green and chocolate colored shales - - -	20	= 69
" 10.	Light gray, shaly limestones - - - - - containing <i>Pseudomonotis</i> and other fossils.	4	= 49
" 9.	Shales, about 4' or more in thickness - - -	4	= 45
" 8.	Dark gray silicious limestone - - - - - on weathered surface, very irregular with rough jagged prominences.	2 ±	= 41
" 7.	Yellowish shales - - - - - argillaceous containing some of the Cottonwood shale fauna.	6	= 39

" 6.	Yellowish blocky shales	-	-	-	-	-	5	=	33
	containing a Lamellibranch fauna of <i>Pseudo-</i> <i>monotis</i> and <i>Aviculopecten</i> , which in places appear to form a massive rough limestone sim- ilar to No. 8.								
" 5.	Greenish shales	-	-	-	-	-	7	=	28
" 4.	Chocolate and drab shales	-	-	-	-	-	4	=	21
" 3.	Shaly limestones	-	-	-	-	-	4	=	17
" 2.	Yellowish shales	-	-	-	-	-	13	=	13
	with abundant fossils in the lower part. <i>Cotton-</i> <i>wood shales</i> .								
" 1.	<i>Cottonwood limestone</i>	-	-	-	-	-			0
	exposed just above railroad switch, 2 <sup>1</sup> +.								

In the above section, the beds from No. 3 to No. 16, inclusive, with a total thickness of 130 feet are regarded as forming the *Neosho formation*. Stratum No. 8 which weathers to a very rough jagged surface, is somewhat similar in lithologic appearance to the "dry bone limestone" in the upper part of the Wabaunsee formation. This limestone has usually been considered magnesian,<sup>2</sup> but the chemical analysis reveals only a trace of magnesia, and to the presence of silica may be ascribed its roughness.<sup>3</sup>

*Palaeontology*.—As described in the above section, the Neosho formation contains green, chocolate and yellow shales, and as the yellow shales approach the lithologic conditions of the Cottonwood, they frequently contain some of the Cottonwood fossils. No. 7 is one illustration of this statement, and the top of

<sup>1</sup> The thickness and lithologic characters of Nos. 3 to 7, inclusive, were obtained in part from the section at the east end of second railroad cut west of Crusher Hill. In the measurement of the lower part of the section I was assisted by Professor Erasmus Haworth of the University of Kansas.

<sup>2</sup> See Prel. Rept. Geol. Surv. Kans. p. 15, where No. 78 of Swallow, a "gray and drab porous limestone, 2 feet," 38 feet above the Cottonwood is evidently this stratum.

<sup>3</sup> The following analysis is by Mr. Warren Finney:

SiO <sub>2</sub>	-	-	-	-	-	15.99	per cent.
CaCO <sub>3</sub>	-	-	-	-	-	77.65	"
Al <sub>2</sub> O <sub>5</sub>	-	-	-	-	-	4.50	"
Fe <sub>2</sub> O <sub>5</sub>	-	-	-	-	-	1.03	"
MgCO <sub>3</sub>	-	-	-	-	-	trace	
						99.17	"
CO <sub>2</sub>	-	-	-	-	-	38.75	"

No. 16, at the summit of the formation just below the lowest stratum of massive limestone and flint, is another.

In the yellow shales of No. 7, exposed in the second railroad cut west of Crusher Quarry Hill, the following species were collected :

1. *Chonetes granulifera*, Owen. (a)
2. *Athyris* (*Seminula*) *subtilita*, (Hall) Newb. = *A. argentea*, (Shep.) Keyes. (rr)
3. *Productus semireticulatus*, (Martin) de Koninck. (c)
4. *Derbya crassa*, (M. and H.) H. and C. (rr)
5. *Meekella striato-costata*, (Cox) White and St. John. (rr)
6. *Rhombopora lepidodendroides*, Meek. (a)
7. *Septopora biserialis*, (Swallow) Waagen. (rr)

In No. 16, immediately below the base of the flint at the brow of Crusher Hill, the following species were obtained :

1. *Chonetes granulifera*, Owen. (c)
2. *Derbya crassa*, (M. and H.) H. and C. (r)
3. *Athyris* (*Seminula*) *subtilita*, (Hall) Newb. = *A. argentea*, (Shep.) Keyes. (rr)
4. *Productus* sp. (rr)
5. *Crinoid* stems. (r)

Certain layers of the coarser shales and limestones of this formation contain a fauna composed largely of Lamellibranchs, and from the yellowish blocky shales of No. 6, in the railroad cut west of Craik's Creek and Crusher Hill, the following species were collected :

1. *Aviculopecten occidentalis*, (Shum) Meek and Worth. (c)
2. *Pseudomonotis Hawni*, (Meek and Hayden). (c)
3. *Meekella striato-costata*, (Cox) White and St. John. (c)
4. *Pseudomonotis Hawni*, (M. and H.), var. *ovata* M. and H. (rr)
5. *Pinna peracuta* Shum. (?) (rr)
6. *Pleurophorus* cf. *oblongus*, Meek. (rr)
7. *Derbya crassa*, (M. and H.) Hall and Clarke. (rr)
8. *Athyris* (*Seminula*) *subtilita*, (Hall) Newb. (rr)
9. *Productus semirecticulatus*, (Martin) de Koninck. (r)
10. *Chætetes* cf. *carbonarius*, Worth. (rr)

11. *Spirorbis* sp. (r)
12. Cf. *Aclis robusta*, Stevens. (r)

In the light gray shaly limestones as exposed on the road up the Crusher Hill—No. 10 of the section—are the following species:

1. *Productus nebrascensis*, Owen. (aa)
2. *Aviculopecten occidentalis*, (Shum.) Meek and Worth. (a)
3. *Pseudomonotis Hawni*, (Meek and Hayden). (a)
4. *Pleurophorus subcostatus*, Meek and Worth. (c.)
5. *Myalina perattenuata*, M. and H. (r)
6. *Myalina kansasensis*, Shum. (rr)
7. *Meekella striato-costata*, (Cox) White and St. John. (rr)
8. *Derbya* cf. *crassa*, (M. and H.) Hall and Clarke. (rr)
9. Cf. *Aclis Swallowiana*, (Gein.) Meek. (c)
10. *Spirorbis* sp. (c)
11. *Edmondia* sp. (rr)
12. *Bellerophon* sp. (rr)
13. *Discina* sp. (rr)
14. *Zaphrentis* sp. (rr)

On the banks of the South Fork of the Cottonwood River at Matfield Green, and by the roadside three-fourths of a mile north of the village are good exposures of a very hard dark gray to bluish shaly limestone. The presence of an abundance of a few species of fossils in this limestone has been noted at various localities and thus forms a characteristic feature of the formation. This horizon belongs, probably, to No. 12 or 13 of the Crusher Hill section, and at Matfield Green is the following fauna:

1. *Pleurophorus subcostatus*, Meek and Worth. (a)
2. *Productus nebrascensis*, Owen. (a)
3. *Aviculopecten occidentalis*, (Shum.) Meek and Worth. (a)
4. *Pseudomonotis Hawni*, (M. and H.) (c)
5. *Pseudomonotis Hawni*, (M. and H. var. *ovata*, M. and H. (c)
6. *Bellerophon* cf. *sublævis*, Hall, or *Urii*, Fleming. (a)
7. Small *Gastropod* cf. *Aclis* sp. (see fig. in Dana's Manual of Geology, Fourth Ed., p. 685, f. 1121). (c)
8. *Myalina* (?) *Swalloyi*, McChesney. (c)
9. *Edmondia* cf. *nebrascensis*, (Geinitz) Meek. (r)

10. *Myalina kansasensis*, Shum. (rr)
11. *Myalina perattenuata*, M. and H. (rr)
12. *Pinna peracuta*, Shum. (rr)
13. *Bellerophon* cf. *Montfortianus*, N. and P. (rr)
14. *Allorisma* cf. *subcuneata*, M. and H. (rr)
15. *Schizodus* cf. *curtiforme*, Walcott. (rr)
16. *Macrochilina angulifera*, White (?) (r)

It will be seen from the above faunas that in this formation we have strata containing Carboniferous fossils only, alternating with strata containing a mixture of Carboniferous and Permian fossils. The yellowish shales with abundant specimens of *Chonetes granulifera*, Owen, contain only Carboniferous fossils, while the blocky shales and dark gray limestones contain such species as *Pseudomonotis Hawni*, Meek and Hayden, *Pleurophorus subcostatus*, M. and Worth., etc., which are usually considered characteristic of the Permian or Upper Carboniferous. On account of the predominance of the strata containing this mixed fauna it seems advisable to consider the Neosho as the lowest formation of the division generally called the Permo-Carboniferous. This classification would not differ greatly from that of Meek and Hayden, as defined in 1867 by Dr. Hayden when he stated that "Meek and Hayden regarded the beds . . . . down so far as to include most, if not nearly all, of Professor Swallow's Lower Permian, as an intermediate connecting series between the Permian and Coal Measures, which, if worthy of a distinct name at all from the latter, should be called Permo-Carboniferous."<sup>1</sup>

<sup>1</sup> Am. Jour. Science, 2d series Vol. XLIV., p. 37. It will be remembered that Swallow called the "dry bone limestone" the base of his Lower Permian, which is about 62 feet below the base of the Neosho formation; and Meek and Hayden did not indicate a precise line of division. Some geologists consider that Meek in his Report on the Paleontology of Eastern Nebraska referred the Permo-Carboniferous and Permian of Kansas to the Carboniferous; but the writer understands that classification to apply only to Nebraska, for Meek said: "All of these strata under consideration along the Missouri . . . . really belong entirely to the true Coal Measures; unless the division C, at Nebraska City, and some apparently higher beds below there on the Missouri, may possibly belong to the horizon of an intermediate series between the Permian and Carboniferous, for which, in Kansas, Dr. Hayden and the writer proposed the name Permo-Carboniferous" (Final Rept. U. S. Geol. Surv. Neb. and adjg. Territories, 1872, p. 130).

*Comparison of the Neosho formation with Swallow's section.*—The Neosho formation includes the upper 25 feet of bed No. 79 of Swallow's section and extends to the base of No. 62—the “fifth cherty limestone.”<sup>1</sup>

These beds all belong in Swallow's Lower Permian, and he gave the thickness as ranging from 111 feet 7 inches to 148 feet 7 inches. Swallow's bed No. 76, which he described as a “soft blue and gray coralline limestone, 3 feet, containing *Monotis Halli*, and *Americana*, *Productus Norwoodi*, *Synocladia biserialis*, *Thamniscus dubius* (?), *Edmondia Hardni*, *Phillipsia Cliftonensis*,”<sup>2</sup> 49 feet above the top of the *Fusulina* limestone, is clearly No. 10 of our section, 45 feet above the Cottonwood limestone. Again, bed No. 68 of Swallow, described as a “hard blue and buff magnesian limestone, containing numerous Permian *Acephala*” from 72 feet 7 inches to 77 feet 7 inches above the *Fusulina* limestone, is probably No. 12 of the Crusher Hill section. Six feet above this limestone Swallow noted a “light buff and drab argillo-magnesian limestone”—No. 66—containing “*Monotis* and *Bakevellia*,” and the limestone noted at the top of our No. 13, eight feet above No. 12, probably belongs to the lower part of Swallow's bed No. 66. The limestone—No. 64 of Swallow—is near the horizon of our No. 15, and below the cherty limestone. Swallow described shales containing “*Synocladia biserialis*, *Productus Norwoodi*, *Orthisina Shumardiana*,” which are the same as the shales with the Cottonwood fauna called No. 16 of the Crusher Hill section. It will be seen that there is a close agreement between the thickness and lithological characters of the section west of Strong City and the beds of Swallow's section, the upper ones of which he described from exposures near Fort Riley on the Kansas River.

*Comparison with Meek and Hayden.*—The Neosho formation on the Kansas River includes the upper 22 feet of Meek and Hayden's No. 23 and terminates at the base of their No. 18, to which Meek and Hayden assigned a thickness of 96 feet.<sup>3</sup> Below

<sup>1</sup> Prel. Rept. Geol. Surv. Kans., pp. 14–16.

<sup>2</sup> Ibid., p. 15.

<sup>3</sup> Proc. Acad. Sci. Phil., Vol. XI., p. 17.



Fort Riley, Meek and Hayden did not find continuous exposures, therefore they underestimated the thickness of the rocks between the Manhattan limestone<sup>1</sup> and the base of the lower flint at Fort Riley. They noted at Fort Riley, however, the shales just below the lower flint with the Cottonwood fossils, and they state that No. 19 "contains near the upper part fragments of Crinoid columns, *Synocladia biserialis*, *Spirigera*, *Productus Norwoodi*, *Chonetes mucronata* [*C. granulifera*], *Orthisina Shumardiana*, *Orthisina umbraculum*, etc., with teeth of *Petalodus Alleghaniensis*."<sup>2</sup>

These yellowish fossiliferous shales, which represent No. 16 of the Crusher Hill section, are well exposed below the massive limestone and flint stratum at the Quartermaster's Bridge at Fort Riley.

#### THE CHASE FORMATION.

Succeeding the Neosho formation are massive limestones and flints separated by beds of variously colored shales which form the region known as the "Flint Hills" of Kansas.

Topographically this is a conspicuous region. Steep hills and bluffs capped by layers of heavy limestone and flint form quite extensive plateaus in which the streams have eroded deep and narrow valleys. Professor Broadhead said this region "might appropriately be termed the Permian mountains."<sup>3</sup>

*Three flint horizons.*—The formation contains three prominent massive limestones with interstratified layers of flint which cap the conspicuous bluffs and produce the characteristic topographic features of the country. These flinty limestones and the interstratified shales, which are 265 feet in thickness, cover the greater part of the western half of Chase county and are well exposed in bluffs along the Cottonwood River and its tributaries. The name *Chase* is therefore considered appropriate for this formation.

In the Cottonwood Valley the lowest of these limestones and flints caps the Crusher Hill west of Strong City, and for convenience in describing the formation this horizon may be called

<sup>1</sup> Manhattan limestone is the local name of the Cottonwood stone in the Kansas River valley.

<sup>2</sup> Ibid., p. 17.

<sup>3</sup> Trans. St. Louis Acad. Sci., Vol. IV., Pt. III., p. 484.

the *Strong flint*, which varies in thickness from 35 to 45 feet. From 110 to 115 feet above the base of the Strong flint is the base of the second massive flint with a heavy limestone above. The horizon is well exposed along the McPherson branch of the A., T. & S. F. R. R., and in the Jones' quarries from one to two miles northeast of Florence. This may be called the *Florence flint and limestone*. The flint strata are 22 feet thick and are separated near the center by a white cellular limestone from one to two feet thick, while above the flint are 40 feet of buff limestone, the lower and upper portions of which are generally more or less shaly, with a massive ledge forming the central portion. The highest flint and limestone is well exposed along the bluffs of the river and small streams near Marion, and its base is about 123 feet above the base of the Florence flint. Near Marion at the base of the flint horizon is a flinty limestone about 4 feet thick, followed by 13 feet of yellowish shales, capped by a zone 10 feet thick, composed of two strata of limestone separated by shales, the limestones containing large irregular concretions which weather to a brown color. The flint is not as uniform in occurrence as in the Florence and Strong flints, so at some localities this horizon is represented simply by a prominent light gray limestone nearly free from flint, and occasionally the particles in the concretionary limestone are small and inconspicuous. As a rule, however, the concretions are large and the stratum may be readily traced across the country either from its exposure in bluffs or streams, or from the line of loose brown concretions crossing the prairie. This limestone has been traced by the writer along its line of outcrop from the center part of Butler county across Chase and Marion counties into Morris county.

This flint and concretionary limestone is the highest prominent flint ledge in the upper Palæozoic of Kansas. It forms a marked stratigraphic horizon that is of great assistance in determining the areal geology of eastern central Kansas, and on account of the good exposures of this zone near Marion City, the horizon has been called the *Marion flint and concretionary limestone*.

*General geologic section of the Chase formation.*—From the

comparison of a large number of individual sections has been prepared the following general section which gives the thickness and lithologic character of the various strata composing the Chase formation.

		Feet.	Feet.
No. 20.	Massive limestone - - - - - containing large flint concretions which weather brown and contain <i>Productus</i> and a few other fossils. It is composed of two layers separated by a thin shale, <i>Marion concretionary limestone</i> .	10	= 265
" 19.	Yellowish shales - - - - - containing a few <i>Brachiopods</i> .	13 +	= 255
" 18.	Light gray limestone - - - - - generally containing flint. <i>Marion flint</i> .	4	= 242
" 17.	Yellowish, chocolate and greenish shales - - with occasional layers of thin limestone.	62 ±	= 238
" 16.	Buff shaly limestones - - - - - containing <i>Lamellibranch</i> fauna.	22	= 176
" 15.	Massive buff limestone. <i>Florence limestone</i> -	5 +	= 154
" 14.	Buff shaly limestone - - - - - containing an abundant <i>Brachiopod</i> fauna.	15	= 149
" 13.	Massive limestone - - - - - with layers of flint.	10	= 134
" 12.	White cellular limestone - - -	2	= 124
" 11.	Massive limestone - - - - - with layers of flint.	10	= 122
" 10.	Yellowish, chocolate and greenish shales - -	31	= 112
" 9.	Light gray limestone - - - - - containing an abundance of small <i>Lamelli-branchia</i> .	2 ±	= 81
" 8.	Shales not well exposed - - - - -	12 ±	= 79
" 7.	Shaly buff limestones - - - - - containing large <i>Brachiopods</i> ; sometimes a massive limestone.	10 ±	= 67
" 6.	Shales, not well exposed - - - - -	15 ±	= 57
" 5.	Massive gray limestone - - - - -	3 ±	= 42
" 4.	Limestone with an abundance of coarse flint and some large brown concretions	10 (?)	= 39
" 3.	Yellowish and rather coarse shale -	3½	= 29
" 2.	Massive light gray to whitish limestones containing some flint -	18	= 25½
" 1.	Light gray limestone with plenty of flint in regular layers. <sup>1</sup> - - -	7½	= 7½

<sup>1</sup> The several beds of the above section are described mainly from exposures near the following localities: Marion concretionary limestone and flint near Marion and Burns; shales of No. 17, east of Cedar Creek near Wonsevu, Chase county; Florence limestones and flint near Florence and Ft. Riley; shales of No. 10, on Middle Creek above Elk, Chase county; Lamellibranch limestone, No. 9, near Four Mile and Six Mile Creeks in the southern part of Morris county; shales and shaly buff limestones of Nos. 6-8 near Cedar Point, Cottonwood Falls and Matfield Green; and the complete series of the Strong flint two miles northeast of Council Grove.

*Palæontology*.—Certain beds of the Chase formation contain numerous fossils which may be divided into two faunas; one composed principally of large Brachiopods and the other of small Lamellibranchia.

The different layers of the Strong flint are sparingly fossiliferous; and at no locality has any considerable number of specimens been obtained. The following species have been noted:

1. *Entelestes hemiplicatus*, (Hall) H. and C.
2. *Athyris* (*Seminula*) *subtilita*, (Hall) Newb.
3. *Chonetes granulifera*, Owen.
4. *Meekella striato-costata*, (Cox) White and St. John.
5. *Productus nebrascensis*, Owen.
6. *Derbya crassa*, (M. and H.) H. and C. (?)
7. *Pseudomonotis Hawni*, (M. and H.)
8. (?) *Glaucanome*, sp.
9. *Echinoid* spine.
10. *Bryozoan* sp.<sup>1</sup>

In the upper part of the Strong flint on the south side of Elm Creek, about three miles west of Council Grove is a very fossiliferous stratum. It is a shaly bluish limestone which probably belongs in No. 3 or the lower part of No. 4 of the Chase formation. The following species were collected at this locality:

1. *Athyris* (*Seminula*) *subtilita*, (Hall) Newb. (aa)  
= *A. argentea*, (Shep.) Keyes.
2. *Derbya crassa*, (M. and H.) H. and C. (a)
3. *Derbya multistriata*, (M. and H.) Prosser. (c)
4. *Productus nebrascensis*, Owen. (c)
5. *Pseudomonotis Hawni*, M. and H. (c)
6. *Aviculopecten occidentalis*, (Shum.) Meek (c)
7. *Rhombopora lepidodendroides*, Meek (a)
8. *Aviculopecten McCoyi*, M. and H. (rr)
9. *Septopora biserialis*, (Swallow) Waagen. (c)
10. *Fenestella Shumardi*, Prout. (a)
11. *Myalina perattenuata*, M. and H. (rr)
12. *Myalina recurvirostris*, M. and W. (?) (rr)

<sup>1</sup>These species were collected at the quarry on the Crusher Hill, west of Strong City and from the high hill two miles east of Alma.

13. *Macrodon sangamonensis*, Worth. (?) (rr)

14. *Phillipsia*, sp. (rr)

In the shaly limestones of No. 7 a few species of large Brachiopods were obtained. West of the Dunlap schoolhouse, two miles north of Matfield Green, the following species were collected:

1. *Derbya multistriata*, (M. and H.) Prosser.<sup>1</sup>

2. *Aviculopecten occidentalis*, (Shum.) Meek (rr)

3. *Myalina recurvirostris*, Meek and Worth (?) (rr)  
shells poorly preserved.

4. *Myalina perattenuata*, M. and H. (?) (rr)

In addition at other localities has been found the following species:

5. *Spirorbis* sp.

Probably the *S. orbiculostoma* of Swallow.<sup>2</sup>

The light gray limestone of No. 9 contains an abundance of a few species of small Lamellibranchia which constitute a characteristic Permian fauna. An exposure west of Wolf Creek, on Sec. 15 of Four Mile township, Morris county, afforded the following species:

1. *Pleurophorus subcuneatus*, M. and H. (a)

2. *Bakevellia parva*, M. and H. (c)

3. *Yoldia* (?) *subscitula*, M. and H. (rr)

4. *Edmondia Calhouni*, M. and H. (?) (r)

Small specimens similar to the form figured by Geinitz as belonging to this species (see Fig. 2, Pl. II., Carb. and Dyas, Nebraska).

5. *Nautilus eccentricus*, M. and H. (?) (c)

6. *Aclis Swallowiana*, (Geinitz) Meek. (r)

7. Small *Gastropod* cf. *Orthonema* sp. (rr)

Specimens showing *Stylolites* structure.

The limestones interstratified with the Florence flint contain

<sup>1</sup>The striae and characters of these specimens apparently agree with the form noted in some of the early papers as *Orthisina umbraculum*, Schloth, sp. (?) for which Meek and Hayden proposed the specific name *O. multistriata* (Proc. Acad. Nat. Sci. Phil., Vol. XI, p. 26).

<sup>2</sup>Described without figure in Trans. Acad. Sci. St. Louis, Vol. I., p. 181.

a small number of species; the following list having been obtained from the bluffs along the railroad northeast of Florence:

1. *Productus semireticulatus*, (Martin) de Koninck. (c)
2. *Productus costatus*, Sowerby. (rr)
3. *Derbya multistriata*, (M. and H.) Prosser. (r)
4. *Chonetes granulifera*, Owen. (c)
5. *Athyris* (*Seminula*) *subtilita*, (Hall) Newb. = *A. argentea*, (Shep.) Keyes. (rr).
6. *Bryozoa*, sp. (rr)
7. *Coral*, sp. (rr)

From other exposures have been obtained the following additional species:

8. *Meekella striato-costata*, (Cox) White and St. John. (c)
9. *Chænomya minnehaha* (Swallow) M. and H. (?) (rr)
10. *Productus nebrascensis*, Owen. (rr)
11. *Sedgwickia* (?) *altirostrata*, Meek and Hayden. (rr)
12. *Phillipsia*, sp. (r)

Probably the most fossiliferous zone of the formation is No. 14, the buff shaly limestones between the Florence flint and the massive limestone. It is essentially a Brachiopod fauna in which there is an abundance of a few large species. In the old quarry one mile northeast of Florence is the following fauna:

1. *Derbya multistriata*, (M. and H.), Prosser. (aa)

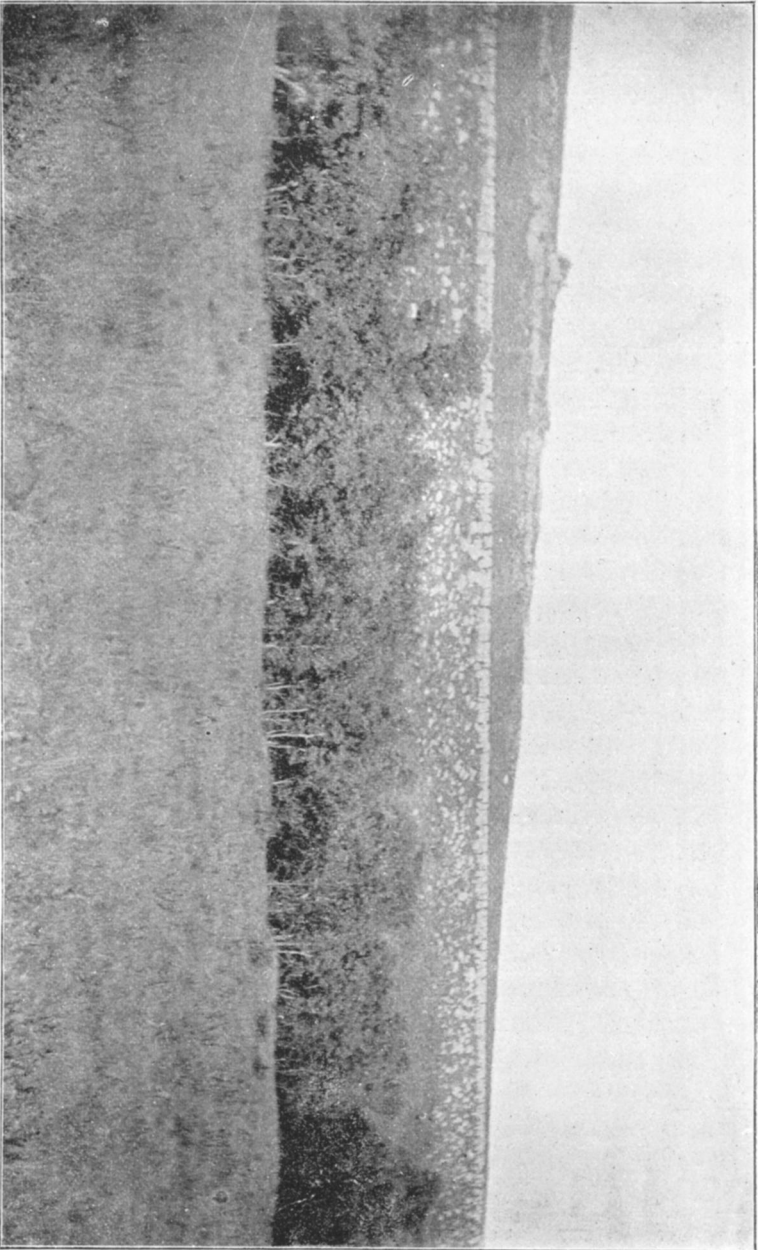
This is probably the species identified by Dr. Newberry, as *Orthisina umbraculum* from the beds of similar age in Morris county.<sup>1</sup>

2. *Athyris* (*Seminula*) *subtilita*, (Hall) Newb. (aa)
3. *Productus semireticulatus*, (Martin) de Koninck, var. *Calhounianus*, Swallow. (a)

Meek considered Swallow's *P. Calhounianus* a synonym of *P. semireticulatus*;<sup>2</sup> but in the Cottonwood and Kansas sections it can usually be distinguished from the *P. semireticulatus*, and it seems distinct enough to be considered a variety.

<sup>1</sup> Rept. Macomb Exp. Exped., p. 21.

<sup>2</sup> Final Rept. Nebraska, Pt. II., p. 161.



No. 3. General appearance of the Fort Riley limestone near the top of the bluff north of Fort Riley, Kansas. Above the Fort Riley limestone are thinner limestones in which fossils are common.

4. *Meekella striato-costata*, (Cox) White and St. John. (a)
5. *Derbya crassa*, (M. and H.) H. and C. (c)
6. *Straparollus* (*Euomphalus*) *subquadratus*, Meek and Worth (c)
7. *Meekella* (?) *Shumardiana*, (Swallow) Williams. (c)
8. *Spirifera* (*Martinia*) *planoconvexa*, Shum. (c)
9. *Aviculopecten occidentalis*, (Shum.) M. and W. (rr)
10. *Straparollus* (*Euomphalus*) *subrugosus*, M. and W. (?) = *S. catilloides*, (Con.) Keyes. (rr)
11. *Pseudomonotis Hawni*, M. and H. (rr)
12. *Schizodus* cf. *Wheeleri*, (Swallow) Meek. (rr)
13. *Allorisma subcuneatum*, M. and H. (rr)
14. *Sedgwickia altirostrata*, M. and H. (rr)
15. *Chænomya minnehaha*, (Swal.) M. and H. (rr)
16. *Polypora submarginata*, Meek. (rr)
17. *Fenestella Shumardi*, Prout (?) (rr)
18. *Chaetetes*, sp. (c)
19. Segments of *Crinoid* stems. (r)

From other exposures in the vicinity of Florence, the following additional species were collected:

20. *Myalina kansasensis*, Shum. (rr)
21. *Myalina perattenuata*, M. and H. (rr)
22. *Pinna peracuta*, Shum. (?) (rr)
23. *Septopora biserialis*, (Swallow) Waagen (rr)
24. *Phillipsia sangamonensis*, M. and W. (?) (rr)
25. *Spirorbis* cf. *permianus*, King. (r)
26. *Edmondia*, sp. (rr)
27. *Archæocidaris*, plates and spines. (c)
28. *Chonetes granulifera*, Owen. (rr)
29. *Aviculopecten* cf. *carboniferous*, (Stevens) Meek. (rr)
30. *Straparollus* (*Euomphalus*) cf. *pernodosus*, M. and Worth. (rr)
30. *Bryozoa*, sp. (rr)

In some localities certain layers of the shaly buff limestones—No. 16 of the section—overlying the more massive limestone contain a Lamellibranch fauna composed of a large number of a few Permian species. The best localities noted for this zone are



in the quarries of the shaly limestones on the Kansas River, one mile west of Junction City and north of Fort Riley. Only a limited time was available for collecting at these localities, but the following list was obtained which would be increased by by more careful search :<sup>1</sup>

1. *Bakevellia parva*, M. and H, (a)
2. *Pleurophorus subcuneatus*, M. and H. (c)
3. *Pleurophorus*, sp. (a)

This is probably the species listed as *Solemya* by Meek and Hayden<sup>2</sup> in their Kansas valley section.

4. *Aviculopecten occidentalis*, (Shum.) Meek and Worth. (c)
5. A small *Gastropod* smooth, internal impressions with seven whorls which taper regularly to the apex. cf. *Loxonema Geinitziana*, King (Mon. Perm. fossils, Pl. XVI., f. 31).
6. (?) *Euomphalus*, sp. (r).

The chocolate and greenish shales—No. 17—overlying the Florence shaly limestones are not fossiliferous; but the yellowish shales contain a few species.

In the Marion flint or limestone—No. 18—is a limited number of fossils which are principally Brachiopods. The following species were obtained in the city of Marion or its vicinity :

1. *Productus semireticulatus*, (Martin) de Koninck, var. *Calhounianus*, Swallow. (r)
2. *Athyris (Seminula) subtilita*, (Hall) Newb. = *A. argentea*, (Shep.) Keyes. (r)
3. *Pinna peracuta*, Shumard. (rr)
4. *Bryozoa*, sp. (rr)
5. *Archæocidaris* spines and plate. (r)

<sup>1</sup> It was in this zone, near Junction City and Fort Riley, that Professor Hay found the *Nautiloidea*, three species of *Metacoceras* and one *Phacoceras* which were described by Professor Hyatt (Geol. Surv., Texas, 2d. An. Rept., 1890, pp. 336, 339, 340, 347). Later, the *Phacoceras Dumbli* was changed to the genus *Stenopoceras* (*Ibid.*, 4th An. Rept., 1893, p. 446). For reference to their stratigraphic position see Professor Hay (Trans. Kans. Acad. Science, Vol. XIII., pp. 37, 38; and Eighth Bien. Rept. State Board Agri., Kansas, Vol. XIII., p. 104, fossils of No. 12 of the Fort Riley section).

<sup>2</sup> Proc. Acad. Nat. Sci., Phil., p. 17, fauna of Bed No. 11.

While in the yellowish shales—No. 19—between the flint and concretionary limestone are:

1. *Athyris (Seminula) subtilita*, (Hall) Newb. = *A. argentea*, (Shep.) Keyes. (c)
2. *Productus semireticulatus*, (Martin) de Koninck. (r)
3. *Derbya multistriata*, (M. and H.) Pros. (?) (rr)
4. *Derbya crassa*, (M. and H.) H. and C. (r)
5. *Septopora biserialis*, (Swallow) Waagen. (r)
6. *Myalina recurvirostris*, M. and W. (rr)
7. *Archæocidaris*, sp. (c)
8. *Aviculopecten*, sp. (rr)
9. (?) *Edmondia*. sp. (rr)
10. *Crinoid* stems.<sup>1</sup>

Finally, in the massive concretionary layers, and in the concretions themselves, are fossils among which Brachiopods are the most numerous and characteristic. The following species were obtained in Marion county:

1. *Athyris (Seminula) subtilita*, (Hall) Newb. = *A. argentea* (Shep.) Keyes. (rr)
2. *Aviculopecten occidentalis*, (Shum.) M. and W. (?) (rr)
3. *Edmondia*, sp. (rr)
4. *Productus semireticulatus*, (Martin) de Koninck. (rr)
5. *Derbya multistriata*, (M. and H.) Prosser. (r)
6. *Septopora biserialis*, (Swallow) Waagen. (r)
7. *Archæocidaris*, sp. (c)
8. *Crinoid* segments.

Palæontologically the Marion concretionary limestone is an important stratigraphic horizon for in the higher fossiliferous rocks Brachiopods are seen at rare intervals and rapidly disappear. The fauna of the succeeding rocks consists almost entirely of Lamellibranchia and is composed of species which are

<sup>1</sup> Professor Broadhead stated that at Marion, "*Aviculopecten occidentalis* and *Fusulina cylindrica* were the only fossils seen" (Trans. St. Louis Acad. Science, Vol. IV., Pt. III., p. 492). I have not yet seen *Fusulina* as high as the Marion horizon and Meek and Hayden did not find them above a thin limestone which they reported as thirty-five feet above the horizon of the Cottonwood limestone (Proc. Acad. Nat. Sci. Phil., Vol. XI., p. 17, No. 22), which would locate it in the lower part of the Neosho formation.

quite universally considered as Permian. As previously stated, the Marion flint and concretionary limestone form a horizon which is readily traced in the field, as well as a clearly marked stratigraphic line, so that it is well adapted to serve as the line of separation between two formations. In fact it is the only sharply defined stratigraphic line in this part of the series, and such a classification is further supported by the almost entire disappearance of Brachiopods, although a few specimens continue somewhat higher in accordance with similar facts noted in reference to other formations.

*Comparison of the Chase formation with Swallow's section.*—

It is perfectly clear from a comparison of the sections that the horizon termed the *Strong flint* in the Chase formation comprises beds No 62–58 inclusive of Swallow, to which he gave a thickness varying from thirty-six to sixty-three feet, and which is called forty-two feet in the Chase formation. The flint stratum at the base of the Chase formation, No. 1 of the section, equals No. 62 of Swallow's list which he called the “fifth *cherty limestone*” and described as “a light drab and buff cherty magnesian limestone,<sup>1</sup> twelve feet” containing “*Productus Calhounianus*, *Chonetes mucronata*, *Orthisina* like *umbraculum*, *Athyris* like *subtilita* and *Crinoids*,” near Fort Riley.<sup>2</sup> Swallow called his bed No. 58 the “fourth *cherty limestone*” which corresponds to No 4 of the Strong flint, and he assigned it a thickness varying from ten to twenty-four feet.

The *Florence flint* represents bed No. 54 of Swallow, the “third *cherty limestone*” which he described as “light buff and magnesian, forty feet” containing “*Productus Calhounianus*, *Orthi-*

<sup>1</sup> The following analysis by Mr. Warren Finney shows that it is not a magnesian limestone.

SiO <sub>2</sub>	-	-	-	-	03.01 per cent.
Al <sub>2</sub> O <sub>3</sub>	-	-	-	-	11.73 “
CaCO <sub>3</sub>	-	-	-	-	86.35 “
MgCO <sub>3</sub>	-	-	-	-	trace “
Fe <sub>2</sub> O <sub>5</sub>	-	-	-	-	trace “
					<hr/> 101.09 “
CO	-	-	-	-	38.32 “

<sup>2</sup> Prel. Rep. Geol. Surv., Kansas, p. 14.

*sina Shumardiana*, *Spirifer* like *lineatus*, *Orthisina* like *umbraculum*" exposed "near Fort Riley, Cottonwood and Fancy Creek."<sup>1</sup>

Swallow estimated the thickness of the beds between the fourth and third cherty limestones, which correspond to the beds between the top of the Strong and the base of the Florence flint, as ranging from forty-nine to sixty-eight feet which in our section is called seventy feet. Again, Swallow estimated the thickness of the beds ranging from the base of the fifth to the third cherty limestone, which represent the beds between the base of the Strong and Florence flints, as varying in thickness from 85 to 131 feet, while in the Chase formation they are assigned a thickness of 112 feet. Swallow reported six feet of shales above the Florence flint and then a massive limestone which he described as "a buff porous magnesian rock<sup>2</sup> in thick beds," containing "*Productus Calhounianus*, *Orthisina Shumardiana*, *Archæocidaris*, *Bakevellia*, etc., eight to ten feet . . . near Fort Riley, Cottonwood and Fancy Creek" for which he proposed the name "*Fort Riley limestone*." On account of the excellent exposures near Junction City and Fort Riley, Swallow's name, "*Fort Riley limestone*," is an appropriate one for the Kansas Valley region, while in the Cottonwood Valley it is represented by the Florence limestone.<sup>3</sup>

After comparing numerous sections, it does not appear that the massive ledge of limestone exposed in the various ravines and bluffs of this region always represents the same bed; in fact we also find that the higher shaly limestones appear in cer-

<sup>1</sup> Prel. Rep. Geol. Surv., Kansas, p. 14. The "Fancy Creek" mentioned frequently by Professor Swallow is supposed to be the one north of the Kansas River in the northern part of Riley county.

<sup>2</sup> This limestone contains a small percentage of magnesia as is shown by Mr. Finney's analysis:

SiO <sub>2</sub>	-	-	-	-	-	10.01 per cent.
Al <sub>2</sub> O <sub>3</sub>	-	-	-	-	-	3.74 "
CaCO <sub>3</sub>	-	-	-	-	-	83.53 "
MgCO <sub>3</sub>	-	-	-	-	-	2.17 "
Fe <sub>2</sub> O <sub>5</sub>	-	-	-	-	-	trace "
						99.45 "
CO <sub>2</sub>	-	-	-	-	-	36.66 "

<sup>3</sup> For the first statement of this correlation see PROSSER; Bull. Geol. Soc., Amer., Vol. VI., p. 49 f. n.

tain localities as the conspicuous massive ledge. It is important to bear the above statement in mind in stratigraphic work in regard to this horizon, for a greater uniformity of appearance in outcrop has been assigned to this limestone than actually exists.

Above the Fort Riley limestone Swallow also reported variously colored shales and marls sixty-four and a half feet in thickness before reaching the base of the "second *cherty limestone*"—bed No. 44—which he described as "hard, bluish drab and very cherty, four feet. *Productus*, *Myalina* and *Spirifer*" exposed on the "Cottonwood and Carey Creek."<sup>1</sup> This bed is probably the *Marion flint* of the Chase formation which answers quite well to the above description. The base of the Florence flint is a clearly marked stratigraphic line, and Swallow assigned a thickness of from 118½ to 120½ feet to the beds between the bases of his third and second cherty limestones, while in the Chase formation, from the base of the Florence flint to that of the Marion, it is given as 126 feet. From sixteen to twenty-four feet above the top of the second cherty limestone is bed No. 40 of Swallow which he called the "first *cherty limestone*" and characterized it as "a brownish-buff magnesian limestone with cherty concretions, four feet. *Productus Calhounianus*, *semi-reticulatus* (?), *Athyris subtilita*?, *Archæocidaris*," exposed on "Cottonwood and Carey Creek."

It is inferred that this "first cherty limestone" of Swallow is the *Marion concretionary limestone* of the Chase formation, and it will be noticed that Swallow mentions "cherty concretions" instead of simply "chert" as in his description of the other cherty limestones, although he does not refer to the prominent stratigraphic feature of this bed.

Finally, Swallow gave the total thickness of the beds from the base of his fifth cherty limestone—No. 62—to the top of the first cherty limestone—No. 40—as ranging from 223½ to 279½ feet.<sup>2</sup> These beds include all the cherty limestones of

<sup>1</sup> Prel. Rep. Geol. Surv., Kansas, p. 13. The Carey Creek frequently mentioned by Swallow is supposed to be the creek of that name in the eastern part of Dickinson county.

<sup>2</sup> In the section there are a few beds to which no thickness was assigned by Swallow, but it is supposed those were regarded as local and simply a modification of the other beds so that their thickness was considered in those beds.

Swallow and represent those which we have described as the Chase formation, with a thickness of 265 feet. The Chase formation is confined to what Swallow called the Lower Permian, and he drew the line separating the Lower from the Upper Permian at the top of bed No. 31 which he gave as from 49 feet 1 inch to 82 feet 3 inches higher than the bed which we regard as representing the top of the Chase formation.

*Comparison with Meek and Hayden.*—The Strong flint corresponds to bed No. 18 of Meek and Hayden, which they described as a "light gray and whitish magnesian limestone containing *Spirigera*, *Orthisina umbraculum* (?), *O. Shumardiana*, *Productus Calhounianus*, *Acanthocladia americana* and undetermined sp. *Cyathocrinus*; lower part containing many concretions of flint. Fort Riley and on Cottonwood Creek, whole thickness about 40 feet; " while in the Chase formation we have called it 42 feet. Again, the Florence flint is bed No. 14 of Meek and Hayden, which they give as 38 feet thick, while the Florence or Fort Riley massive limestone is No. 12, which they state "forms distinct horizon near summit of hills in vicinity of Fort Riley, also seen on Cottonwood Creek—7 to 8 feet." Number 11 of Meek and Hayden represents the shaly limestones above the massive Florence limestones (No. 16 of the Chase section) which they describe as a "light grayish and yellow magnesian limestone in layers and beds, sometimes alternating with bluish and other colored clays, and containing *Solenomya*, a *Myalina* near *squamosa*, *Pleurophorus* (?) *subcuneata*, *Bakevellia parva*, *Pecten*, undt., and a *Euomphalus* near *E. rugosus*; also a *Spirigera* allied to *S. subtilita* but more gibbous, *Orthisina umbraculum* (?), *O. Shumardiana*, etc. Locality, summit of the hills near Fort Riley and above there; also seen on Cottonwood Creek—25 to 35 feet." Meek and Hayden gave the thickness of the beds from the base of the lower flint—No. 18—to the top of these buff, shaly limestones—No. 11—as ranging from 182 to 193 feet; while in our section of the Chase formation the thickness of the same beds is given as 176 feet. Meek and Hayden considered that the base of the Permian could

<sup>1</sup> Proc. Acad. Sci. Phil., Vol. XI., p. 17.

not be lower than the top of No. 11, although it might be still higher and include No. 10.<sup>1</sup>

Meek and Hayden apparently failed to notice the Marion flint and concretionary limestone, which probably forms a part of their No. 10, so it is not possible to compare closely their section with the upper part of the Chase formation.

*Comparison with Hay's Fort Riley section.*—Professor Hay has described a section near Fort Riley<sup>2</sup> which probably includes all of the rocks referred to the Chase formation. The Strong flint is No. 5 of Hay's section, which he termed "the lower flint beds" or the "Wreford limestone," 25 feet thick.<sup>3</sup>

The Florence flint is No. 9 of Hay, which he called "the upper flint beds," from 25 to 30 feet in thickness; and 15 feet higher in his massive "Fort Riley main ledge"—No. 11—6 feet thick, capped by shaly limestones from 30 to 40 feet in thickness. Then come 50 to 60 feet of shales, and at the top of the section is No. 14 which is described as composed of "impure limestones with some flints and numerous geodes," 10 feet in thickness. It is probable that this highest bed represents the Marion flint or concretionary limestone, which apparently occurs in the bluff above the railroad cut west of Chapman. According to Professor Hay, the thickness of the rocks from the base of the Wreford

<sup>1</sup> Proc. Acad. Sci. Phil., Vol. XI., pp. 20, 21, where it is stated that, "If we do not admit the existence in this region of an intermediate group of rocks, connecting by slight gradations the Permian above with the Coal Measures below, and must draw a line somewhere, below which all is to be regarded as Carboniferous, and all above as Permian, we should certainly, upon palæontological principles alone, carry this line up as far as the top of division No. 11. . . . Indeed the fact that some of the Permian types occurring in No. 10 were first introduced in beds below this, containing many Carboniferous species would seem to indicate that even No. 10 may possibly have been deposited just before the close of a period of transition from the conditions of the Carboniferous to those of the Permian epoch."

About the same time Meek and Hayden stated in the American Journal of Science—"We think only the Upper Permian of their section [Swallow and Hawn] really represents the Permian rocks as developed on the other side of the Atlantic" (Second series, Vol. XXVII., Jan. 1859, p. 35); while the Lower Permian of Swallow they called Permo-Carboniferous.

<sup>2</sup> Eighth Bien. Rept. State Board Agri. Kansas, p. 104.

<sup>3</sup> This horizon as exposed in the Kansas River Valley was discussed by Prosser in the Bull. Geol. Soc. Am., Vol VI., pp. 47, 48.

limestone to the top of the impure limestone at the summit of the section—No. 14—varies from 213 to 238 feet. However, the Professor underestimated the thickness of the rocks from the base of the Wreford limestone to the base of the upper flint at Fort Riley by about 27 feet,<sup>1</sup> and if this be added to the 238 feet it will give a thickness of 265 feet, which is exactly the thickness which we have assigned to the Chase formation.

#### THE MARION FORMATION.

Succeeding the Chase formation are thin, buff limestones and shales; higher, marls and shales with gypsum; and lastly, colored shales and marls which continue to the base of the brown Dakota sandstones of the Cretaceous. These rocks cover the greater part of Marion county and are exposed in many places so it is proposed to call them the *Marion formation*. The natural opportunities are not as favorable for constructing an accurate section here as in the Chase formation, on account of the comparatively level character of the region, presenting few steep bluffs and strata that may be readily traced across the country. The rocks composing the formation are estimated to have a thickness of 400 feet.

Some 50 to 60 feet above the Marion and concretionary limestone is a buff limestone which contains large numbers of small *Lamellibranchia* and twenty feet higher is a buff limestone containing large *Lamellibranchia*. In some localities near this horizon is a limestone containing *Pleurophorus* in which are large concretions; these are well shown on sections 34 and 27, north of Wonsévu. On Turkey Creek, south of the Smoky Hill Valley and Abilene, is a conglomerate rock from 15 to 20 feet thick, which is some 150 feet above the base of the formation. On the south bank of the river opposite Abilene is a buff limestone containing *Lamellibranchia*, which is probably a little below the conglomerate.

*Palæontology*.—In the Marion formation but few Brachiopods

<sup>1</sup> Professor Hay gave 77 feet as the thickness of the rocks from the base of the lower flint (Wreford limestone) to the base of the upper flint beds; while I found the thickness of the same rocks to be near 104 feet on the hill at Fort Riley.



have been found, and the most abundant and characteristic fossils are the small Lamellibranchia which are not uncommon in the lower part, but gradually become rare in the upper portion until fossil forms almost entirely disappear.

In the grayish limestones in the lower part of the formation the following species, from numerous localities in Marion and Morris counties, have been obtained :

1. *Pleurophorus subcuneatus*, M. and H. (aa)
2. *Bakevellia parva*, M. and H. (c)
3. *Yoldia subscitula*, M. and H. (rr)
4. *Macrochilina* cf. *angulifera*, White. (rr)
5. *Pleurophorus subcostatus*, M. and W. (?) (rr)
6. *Nautilus eccentricus*, M. and H. (?) (rr)
7. *Schizodus curtus*, M. and W. (r)
8. *Schizodus ovatus*, M. and H. (r)
9. *Dentalium Meekianum*, Geinitz. (?) (rr)

A little higher are buff limestones which contain large Lamellibranchia as follows :

1. *Aviculopecten occidentalis*, (Shum.) Meek. (aa)
2. *Myalina permiana*, (Swallow) M. and H. (a)
3. *Pseudomonotis Hawni* (M. and H.) (a)
4. *Pseudomonotis Hawni* (M. and H.) var. *ovata*, M. and H. (r)

In Township 22 S., Range 6 E., Sec. 18, west of Wonsevu, a limestone near the top of the hill west of Cedar Creek, contains the fauna given below :

1. *Pseudomonotis Hawni* (M. and H.) var. *ovata*, M. and H. (r)
2. *Pseudomonotis Hawni* (M. and H.) (c)
3. *Pseudomonotis* cf. *variabilis*, Swallow. (r)
4. *Pleurophorus subcuneatus*, M. and H. (c)
5. *Nautilus eccentricus*, M. and H. (?) (r)
6. *Aviculopecten occidentalis*, (Shum.) M. and W. (rr)
7. *Yoldia subscitula*, M. and H. (rr)
8. *Nuculana bellistriata*, Stevens, var. *attenuata*, Meek. (rr)
9. *Derbya multistriata*, (M. and H.) Pros. (?) (c)
10. *Septopora biserialis*, (Swal.) Waagen. (?) (rr)

From the buff limestones and shales on the south bank of

the Smoky Hill River, south of Abilene, and not far below the Abilene conglomerate, the following species were collected:

1. *Pleurophorus subcuneatus*, M. and H. (a)
2. *Bakevellia parva*, M. and H. (c)
3. *Edmondia Calhouni*, M. and H. (?) (c) As identified by Geinitz (see Pl. II., Fig. 2 of Carb. und Dyas Nebraska).
4. *Yoldia subscitula*, M. and H. (rr)
5. *Schizodus curtus*, M. and W. (?) (rr)
6. *Nucula* cf. *Beyrichi*, v. Schaueroth; also cf. *N. parva*, McChesney. (a)
7. *Aviculopecten* (?) sp. (rr) }
8. *Septopora* (?) sp. (rr) } very imperfectly preserved.
9. Small *Gastropod* cf. *Aclis Swallowiana*, (Geinitz) Meek. (r)

Above this horizon the fossils are less frequent and in the upper part of the formation seem to completely disappear.

*Comparison of the Marion formation with Swallow's section.*—

The Marion formation commences with bed No. 39 of Swallow, but I have not been able to clearly identify the different beds of his section with the various strata of this formation as in the Chase, Neosho, and Cottonwood formations. Swallow described bed No. 23 as "bluish-drab shale, with calcareous concretions," below which are limestones "full of Permian *Acephala* and *Cephalopods*,"<sup>1</sup> and gave this bed as from 49 feet 1 inch to 103 feet 9 inches above the top of his first cherty limestone, which I have considered as the representative of the Marion concretionary limestone. The thickness of the rocks between the concretionary layer of bed No. 23 and the base of the formation indicate that it may be the upper concretionary layer which I have described northeast of Wonsevu. From 16 to 48 feet higher is the base of a "calcareous conglomerate" 1 to 24 feet thick—bed No. 17—and above this is a "concretionary limestone," 2 to 15 feet in thickness, which are stated to occur in "Fancy and Turkey Creeks and Cottonwood."<sup>2</sup> The maximum thickness of the rocks from the base of the calcareous conglom-

<sup>1</sup> Prel. Rept. Geol. Surv. Kans., p. 12.

<sup>2</sup> Ibid., p. 11.

erate to the base of our Marion formation, according to Swallow, is 151 feet 7 inches, which indicates that the conglomerate we noted in Turkey Creek, south of Abilene, and estimated as 150 feet above the base of the Marion formation is the "calcareous conglomerate" of Swallow. From 61 to 124 feet higher is the top of Swallow's Permian; but Professor Mudge stated that all of Swallow's Triassic system, except the two upper beds—Nos. 3 and 2—should be referred to the Permian.<sup>1</sup> Calling bed No. 4 of Swallow the top of the Permian, the beds of his section corresponding to those of the Marion formation have a thickness ranging from 334 feet 11 inches to 544 feet 7 inches.

*Comparison with Meek and Hayden.*—The conglomerate noted on Turkey Creek south of Abilene is apparently bed No. 9 of Meek and Hayden which they described as a "rough conglomerated mass, composed of fragments of magnesian limestone and sandstone, with sometimes a few quartz pebbles, cemented by calcareous and arenaceous matter . . . south side Smoky Hill River, ten or twelve miles below Solomon's Fork, 18 feet."<sup>2</sup>

From the base of this conglomerate limestone to the apparent base of the Dakota sandstone of their section—bed No. 2—is 388 feet. If their concretionary limestone—bed No. 9—which, according to the description and locality agrees with the one seen south of Abilene, be 150 feet above the base of the Marion formation, then making this correction in their estimate of thickness would give 538 feet as the thickness of the Marion formation.

#### CONCLUSION.

The length of this paper precludes any complete discussion of the geologic position of these formations and their correlation with deposits of similar age in different parts of the world, therefore such a review must be deferred until the detailed geo-

<sup>1</sup> First Bien. Rept. State Board Agri. Kansas, 1878, p. 66 and f. n., where the Professor said, "the other numbers [aside from 2 and 3] of his Triassic belong to the Permo-Carboniferous." Professor Mudge did not attempt to separate the Permian and Upper Carboniferous, for he said, "These two groups may be described together, as there is no line of division, either by physical deposits or fossils" (*ibid.*, p. 70).

<sup>2</sup> Proc. Acad. Nat. Sci., Philadelphia, Vol. XI., p. 16.

logic report of the region is published. In order to appreciate the questions involved in the correlation of these formations, it is important to mention briefly the proposed classifications which have appeared within the last few years.

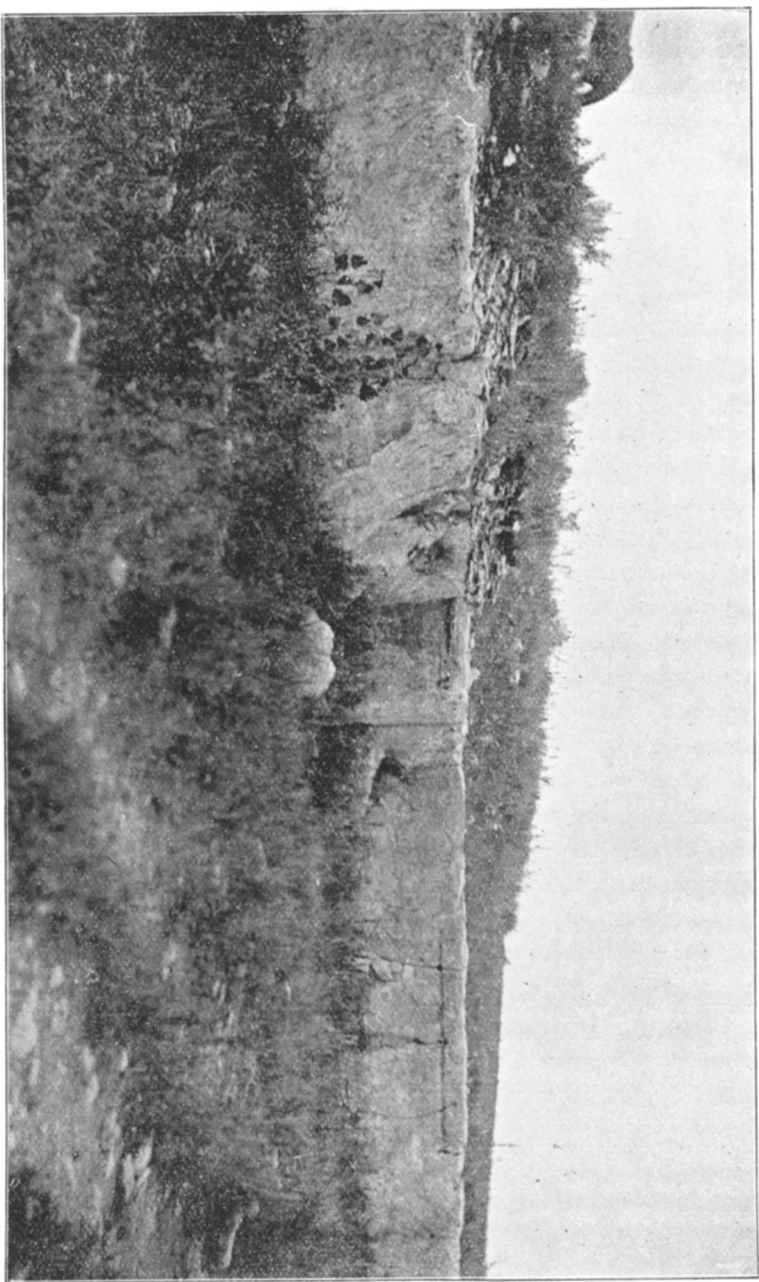
After the publication of the final views of Meek and Hayden in 1872, which referred especially to the Upper Palæozoic of southeastern Nebraska,<sup>1</sup> the next important announcement was that of Dr. Newberry at the Berlin International Geological Congress in 1885, where he is reported to have stated that "He had traversed all the States and Territories of the Union, and had examined the so-called Permian in many localities, but, in his judgment, it could not be separated from the Coal Measures.

It is true that in the upper Carboniferous strata certain genera of mollusks appear, which are regarded as characteristic of the Permian, such as *Monotis*, *Bakevellia*, *Pleurophorus*, etc., but these are associated with and outnumbered by the most characteristic Coal-measure forms, such as *Spirifer cameratus*, *Athyris subtilita*, *Productus semireticulatus*, etc., and were by these inseparably bound to the Carboniferous system."<sup>2</sup> As far as the palæontology is concerned we have shown above that the statement of Dr. Newberry is entirely incorrect in regard to the range of the Brachiopods in Kansas. We have not seen *Spirifer cameratus* above the top of the Wabaunsee formation, or the last two species above the Chase formation. However, the most misleading part of the statement is that these Brachiopods outnumber the Lamellibranchia in all of these deposits. In the Neosho and Chase formations possibly the Brachiopods are the more abundant; but in the Marion formation they are extremely rare, a few specimens of *Derbya* only having been found, and the Permian Lamellibranchia are conspicuously the dominant fossils.

In 1889, Dr. Th. Tschernyschew, the able Director of the

<sup>1</sup> Final Rept. U. S. Geol. Surv. Nebraska and portions of adjacent Territories. The field work upon which this report was based, was accomplished during 1867, and the report was submitted for publication on March 1, 1868, but was delayed until 1872 (see pp. 3, 139).

<sup>2</sup> The Work of the International Congress of Geologists, 1886, p. 29. Dr. Newberry's statement of the absence of the Permian in America was published in the *Am. Jour. Sci.*, 3d series, Vol. XXX., December, 1885, p. 469.



No. 4. Near view of the Fort Riley limestone North of Fort Riley, Kansas.

Russian Geological Survey, stated that he agreed with Waagen in considering the Nebraska City beds, in southeastern Nebraska, similar in age to the Artinsk sandstone group of the Ural Mountains, which he called Permo-Carboniferous.<sup>1</sup>

In 1891 appeared Waagen's exhaustive work on the geological classification of the Upper Palæozoic rocks of the Salt-Range in northern India,<sup>2</sup> in which the author shows the striking relations "that undoubtedly exist between the American Coal Measures and the deposits of the Salt-Range."<sup>3</sup> Waagen followed Neumayr and made two large divisions of the Palæozoic; for the upper division, which included the Carboniferous and Permian systems, he proposed the name, "Anthracolithic epoch" which he defined as equivalent to Neumayr's "Upper Palæozoics."<sup>4</sup>

Waagen prepared a table giving his views of the correlation of the Upper Palæozoic strata of the Salt-Range with similar deposits of other countries,<sup>5</sup> and the Permian system was composed of the Permo-Carboniferous, Rothliegendes, and Magnesian Limestone groups. The correlation of the American deposits are of special interest to us, and represents that part of the table to which we shall refer. Waagen, for North America, drew the dividing line between the Carboniferous and Permian systems at the top of the "Upper Productive Coal Measures" and referred the "marine beds of Plattsmouth [Nebraska] and beds below (up to about 2000 feet in thickness) down to the

<sup>1</sup> *Mém. Com. Géologique*, Vol. III., No. 4, p. 366. In Murchison's description of the geology of Russia, the Artinsk sandstones were referred to the Carboniferous (*Geol. Russia in Europe and the Ural Mts.*, Vol. I., 1845, p. 129). The correlation and palæontology of the Nebraska City beds have been carefully discussed by Professors Marcou, H. B. Geinitz and Meek, and the consideration of this question is reserved for a later paper. Professor Hicks at a later date briefly described deposits in Gage county, in the southern part of Nebraska, which probably belong to the Permo-Carboniferous or Permian of Kansas (*Am. Naturalist*, Vol. XX., 1886, pp. 881-3; abstract in *Proc. Am. Asso. Adv. Science*, Vol. 35, 1887, pp. 216, 217).

<sup>2</sup> *Mem. Geol. Surv. India, Palæ. India. Ser. XIII., Salt-Range Fossils*, Vol. IV., Pt. II., Geological Results, Calcutta.

<sup>3</sup> *Ibid.*, p. 201.

<sup>4</sup> *Ibid.*, p. 241.

<sup>5</sup> *Ibid.*, "Tabular view showing the relations of the Salt-Range Upper Palæozoic strata to the deposits of other countries," *op. cit.*, p. 238.

Productive Coal Measures," to the Permo-Carboniferous group. The upper part of the group was correlated with the Artinsk stage of Russia.

This group would include at least the Wabaunsee formation of Kansas which contains a fauna practically identical with that of the Upper Coal Measures, and as far as the deposits of Kansas are concerned there seems to be no reason for considering the formation as of Permian or Permo-Carboniferous age. The "red and gray sandstones and shales of Nebraska City" are correlated with the Rothliegendes by Waagen, who clearly regards them as younger than the Artinsk stage. Then the "red sandstones and shales of Texas" containing Vertebrates and Cephalopods, which have been described by Cope and White,<sup>1</sup> are referred to the lower part of the Magnesian limestone which forms the upper group of Waagen's Permian system. Finally, the "limestones and shales, with *Pseudomonotis hawni* (*—speluncaria*) of Kansas, red gypsum beds of Texas" are regarded as equivalent to the remaining portion of the Magnesian limestone group and consequently represent the upper part of the Permian system.

It may be said in general in reference to Waagen's correlations that so far as the North American deposits are concerned he carried the Permo-Carboniferous group too low. If it be considered better to put all the beds in either the Carboniferous or Permian system, it might be just as well to refer the deposits generally called Permo-Carboniferous to the Permian.<sup>2</sup> If such correlation be agreed upon then in Kansas, the line separating the Cottonwood and Neosho formations would become the line of division between the Carboniferous and Permian systems. In the Cottonwood formation is the massive *Fusulina* limestone<sup>3</sup>

<sup>1</sup> EDWARD D. COPE: Trans. Am. Phil. Soc., 1888, Vol. XVI., pp. 285-288.

CHARLES A. WHITE: The Texan Permian and its Mesozoic types of fossils. Bull. U. S. Geol. Surv., No. 77, 1891, pp. 39, Pl. IV.

<sup>2</sup> In this connection see a paper by Professor James P. Smith on "The Arkansas Coal Measures in their relations to the Pacific Carboniferous province" (The JOURNAL OF GEOLOGY, Vol. II., 1894, pp. 187-205). On the "Correlation Table" at the close of the paper (p. 204) the "Permo-Carboniferous of Kansas and Nebraska" is referred to the Permian.

<sup>3</sup> The *Fusulina* limestones of Europe and Asia belong either in the Upper Carboniferous or lower Permian, hence, the massive Cottonwood limestone with its millions of

with the fossiliferous shales above, which is an excellent formation to be traced in the field, and so would furnish a well-marked line for separating the two systems in areal geology.

In 1890, Professor W. F. Cummins divided the Texan Permian<sup>1</sup> into three formations or beds, as he called them, and named them in ascending order the Wichita, Clear Fork, and Double Mountain beds.<sup>2</sup> In the succeeding report the upper formations of the Coal Measures were named the Albany, Cisco, and Canyon,<sup>3</sup> the Albany being the higher and just below the Permian according to Professor Cummins' classification. The report also contains plates showing the classification of the Carboniferous and Permian,<sup>4</sup> and lists of fossils from the Coal Measures.<sup>5</sup> The Permian is more fully described than in the preceding reports and is accompanied by sections and references to the palæontology<sup>6</sup> as elaborated by Dr. White.<sup>7</sup> The fossil plants collected in the upper part of the Wichita formation were identified by Professor I. C. White and Fontaine as essentially the same as the flora described by them from the beds above the Waynesburg Coal in West Virginia which they had referred to the Permian.<sup>8</sup> In 1893 Professor Cummins again discussed the Permian formations of Texas, reviewed the history of the discovery of Permian rocks in this country, and the question of their correlation with the Permian of Europe and Asia.<sup>9</sup> In this report

*Fusulinas*, which is near the close of their range in Kansas, may be considered as near the line of division between these two systems. See Dr. E. Kayser's Text Book of Comparative Geology, English ed., 1893, pp. 127, 144, 162. On p. 147 Kayser says "west of the Mississippi . . . the Upper Carboniferous is represented by limestones rich in *Fusulina* with an abundant marine fauna."

<sup>1</sup> For an earlier summary of the papers describing the Permian of Texas, see Professor R. T. Hill; Bull. U. S. Geol. Surv., No. 45, 1887, pp. 62-69.

<sup>2</sup> Geol. Surv. Texas, First An. Rept., pp. 186-189; and LXIX., LXX.

<sup>3</sup> Second An. Rept. Geol. Surv. Texas, 1891, pp. 372-375.

<sup>4</sup> *Ibid.*, pp. 361, 373.

<sup>5</sup> *Ibid.*, Particularly pp. 393, 394.

<sup>6</sup> *Ibid.*, pp. 394-424.

<sup>7</sup> Bull. U. S. Geol. Surv., No. 77.

<sup>8</sup> Bull. Geol. Soc. Amer., Vol. III., 1892, pp. 217, 218.

<sup>9</sup> Geol. Surv. Texas, Fourth An. Report., pp. 212-232.



it is stated: "It is still too early to attempt exact correlation, but it is quite probable that the Albany division of my Coal Measures will prove to be the same as the beds at Fort Riley, Kansas."<sup>1</sup> Professor Cummins further said that the *Phacoceras Dumbli*, Hyatt which is found at Fort Riley, Kansas, came from "the very top of the Albany division in Texas . . . and as the form is supposed to have but a short range in time it would go far to assist in correlating the strata."<sup>2</sup> If Professor Cummins be correct in the above correlation, then it is probable that the Albany formation ought to be correlated with the Permo-Carboniferous of Kansas.<sup>3</sup>

In reviewing these reports Professor Marcou correlated the Albany division with the Nebraska City deposits of Nebraska, and the Cisco division he considered as related to the Plattsmouth group of Nebraska.<sup>4</sup> While Professor Smith draws the line between the Coal Measures and the Permo-Carboniferous through the upper part of the Cisco formation, including in the Permo-Carboniferous the "uppermost Cisco beds of Texas, with *Ammonites (Popanoceras) Parkeri*, Heilprin," which he correlates with the Artinsk stage.<sup>5</sup>

After reviewing all the published opinions regarding the correlations of the Upper Palæozoic of the United States and after a consideration of the fauna and the lithological and stratigraphical characters of these formations as exposed in Kansas, it seems well to classify them as indicated on the chart on p. 797. Consequently we would refer the Wabaunsee and Cottonwood formations to the Upper Coal Measures. The Neosho and Chase formations are transitional from the Upper Coal Measures to the Permian, as first defined by Murchison for Russia, and belong to the division which has generally been called Permo-Carboniferous, in this country. In accordance with the views of the majority of

<sup>1</sup> Ibid., p. 222.

<sup>2</sup> Ibid., p. 223.

<sup>3</sup> Professor Cummins is not sure but that "the Wichita and Albany divisions are but different facies of the same formation" (ibid., p. 223).

<sup>4</sup> Am. Geol. Vol. X., 1892, p. 369; see "Table of Classification" on pp. 376, 377.

<sup>5</sup> JOURNAL GEOLOGY, Vol. II., 1894, p. 194; see "Correlation Table" on p. 204.

present European geologists familiar with this problem it is probably better to include the Permo-Carboniferous rocks of Kansas in the Permian series.<sup>1</sup> We see no decided objection to such a classification, while the appearance and the prominence of the *Pseudomonotis* fauna in the Neosho formation furnishes a strong reason on the biologic side for such correlation. The Marion formation belongs to the undoubted Permian and contains only fossils which are characteristic of that series.

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Schenectady, N. Y., July, 1895.

<sup>1</sup> The classification of the Permian as a subdivision of the Carboniferous period or system is in accordance with the usage of the U. S. Geological Survey (See Tenth An. Rept. U. S. Geol. Surv., p. 66).

TABLE SHOWING THE STRATIGRAPHIC POSITION AND CHARACTER OF THE FORMATIONS COMPRISING THE UPPER PALÆOZOIC OF CENTRAL KANSAS.

PERIOD	SERIES	FORMATION OR STAGE	STRATIGRAPHIC CHARACTERS OF THE DIFFERENT BEDS	CHARACTERISTIC FOSSILS	THICKNESS OF BEDS	TOTAL THICKNESS	THICKNESS OF FORMATION
Cretaceous.		<i>Dakota</i> <sup>1</sup> (Meek and Hayden)	Massive dark brown or red sandstones.	Fossil plants.			
			Various colored shales and marls. Colored shales and marls alternating with beds of gypsum. Buff limestones and marls.		250±	1390	
Carboniferous.	Permian.	<i>Marion</i> (Prosser)	<i>Abilene conglomerate</i> .		20±	1140	400±
			Shaly buff limestones with <i>Pleurophorus</i> .	<i>Pleurophorus subcuneatus</i> , <i>Bakewellia parva</i> , <i>Edmondia Calhouni</i> , <i>Nucula</i> sp.			
			Buff limestones which contain large <i>Lamellibranchia</i> .	<i>Aviculopecten occidentalis</i> , <i>Myalina permiana</i> , <i>Pseudomonotis Hawni</i> .			
			Grayish (?) limestones containing plenty of <i>Bakewellias</i> , near this horizon in some localities a concretionary limestone. Thin buff limestones with a few <i>Derbyas</i> .	..... <i>Pleurophorus subcuneatus</i> , <i>Bakewellia parva</i> , <i>Schizodus curtus</i> , <i>Schizodus ovatus</i> , <i>Nautilus eccentricus</i> , <i>Yoldia subcistula</i> .	130	1120	
			<i>Marion concretionary limestone</i> ; containing large brown concretions.	<i>Athyris subtilita</i> , <i>Productus semireticulatus</i> , <i>Derbya multistriata</i> .			
		<i>Chase</i> (Prosser)	Yellowish shales, few <i>Brachiopods</i> .	<i>Athyris subtilita</i> , <i>Productus semireticulatus</i> , <i>Derbya crassa</i> , <i>Sepiophora biserialis</i> .	10	990	
			<i>Marion flint</i> ; light gray limestone generally containing flint.	<i>Athyris subtilita</i> , <i>Productus semireticulatus</i> , var. <i>Calhounianus</i> , <i>Athyris subtilita Archeocidaris</i> sp.	13+	980	
					4	967	

<sup>1</sup> Perhaps the base of the Dakota should be referred to the Mentor beds of Professor Cragin. (See Am. Geol., Vol. XVI., Sept. 1895, pp. 162, 163.)

TABLE SHOWING THE STRATIGRAPHIC POSITION AND CHARACTER OF THE FORMATIONS COMPRISING THE UPPER PALÆOZOIC OF CENTRAL KANSAS.—Continued.

PERIOD	SERIES	FORMATION OR STAGE	STRATIGRAPHIC CHARACTERS OF THE DIFFERENT BEDS	CHARACTERISTIC FOSSILS	THICKNESS OF BEDS	TOTAL THICKNESS	THICKNESS OF FORMATION
Carboniferous.	Permian.	Chase (Prosser)	Variously colored shales with thin layers of limestone.		62±	963	265
			Buff shaly limestones with <i>Lamellibranch</i> fauna.	<i>Bakewellia parva</i> , <i>Pleurophorus subcuneatus</i> , <i>Aviculopecten occidentalis</i> .	22	901	
			<i>Ft. Riley</i> or <i>Florence limestone</i> ; a massive buff limestone.		5+	879	
			Buff shaly limestones containing an abundant <i>Brachiopod</i> fauna.	<i>Derbya multistriata</i> , <i>Athyris subtilita</i> , <i>Productus semireticulatus</i> var. <i>Calhounianus</i> , <i>Meekella striato-costata</i> , <i>Stropharolius subquadratus</i> , <i>Derbya crassa</i> , <i>Meekella</i> (?) <i>Shumardiana</i> , <i>Spirifera planoconvexa</i> , <i>Chaetetes</i> sp.	15	874	
			<i>Florence flint</i> ; a massive limestone with prominent layers of flint.	<i>Productus semireticulatus</i> , <i>Chonetes granuifera</i> , <i>Derbya multistriata</i> .	22	859	
			Yellowish, chocolate and greenish shales.		31	837	
			Light gray limestone with a fauna of small <i>Lamellibranchia</i> .	<i>Pleurophorus subcuneatus</i> , <i>Bakewellia parva</i> , <i>Edmondia Calhouni</i> (?)	2±	806	
			Shales.		12±	804	
			Shaly buff limestone containing large <i>Brachiopods</i> .	<i>Derbya multistriata</i> , <i>Aviculopecten occidentalis</i> .	10±	792	
			Shales.		15±	782	

TABLE SHOWING THE STRATIGRAPHIC POSITION AND CHARACTER OF THE FORMATIONS COMPRISING THE UPPER PALÆOZOIC OF CENTRAL KANSAS.—Continued.

PERIOD	SERIES	FORMATION OR STAGE	STRATIGRAPHIC CHARACTERS OF THE DIFFERENT BEDS	CHARACTERISTIC FOSSILS	THICKNESS OF BEDS	TOTAL THICKNESS	THICKNESS OF FORMATION
Carboniferous.	Permian.	<i>Chase</i> (Prosser)	<i>Strong flint</i> ; two strata of light gray limestone containing an abundance of flint in layers, separated by a massive whitish limestone.	<i>Entelites hemiplicatus</i> , <i>Athyris subtilita</i> , <i>Chonetes granulifera</i> , <i>Meckella striato-costata</i> .	42	767	
			Yellowish shales with <i>Brachiopod</i> fauna.	<i>Chonetes granulifera</i> , <i>Derbya crassa</i> , <i>Athyris subtilita</i> .	23	725	
			Massive gray limestone with <i>Pleurophorus</i> .		3+	702	
		<i>Neosho</i> (Prosser)	Yellowish shales with thin shaly limestones.		36	699	
			Limestone with <i>Pseudomonotis</i> at top and bottom, with shales between.	<i>Pseudomonotis Harvi</i> .	12	663	
			Green and chocolate colored shales.		20	651	130
			Light gray shaly limestones containing <i>Pseudomonotis</i> .	<i>Productus nebrascensis</i> , <i>Pseudomonotis Harvi</i> , <i>Aviculopecten occidentalis</i> , <i>Pleurophorus subcostatus</i> .	4	631	
			Shales.		4	627	
			Dark gray silicious limestone, weathers to very rough surface.		2+	623	
			Yellowish shales with <i>Brachiopods</i> .	<i>Chonetes granulifera</i> , <i>Productus semireticulatus</i> , <i>Rhombopora lepidodendroides</i> .	6	621	
			Yellowish, blocky shales containing a <i>Lamelli-branch</i> fauna.	<i>Pseudomonotis Harvi</i> , <i>Aviculopecten occidentalis</i> , <i>Meckella striato-costata</i> .	5	615	

TABLE SHOWING THE STRATIGRAPHIC POSITION AND CHARACTER OF THE FORMATIONS COMPRISING THE UPPER PALÆOZOIC OF CENTRAL KANSAS.—*Continued.*

PERIOD	SERIES	FORMATION OR STAGE	STRATIGRAPHIC CHARACTERS OF THE DIFFERENT BEDS	CHARACTERISTIC FOSSILS	THICK- NESS OF BEDS	TOTAL THICK- NESS	THICK- NESS OF FORMA- TION	
Carboniferous.	Upper Coal Measures.	Permian.	(?)					
			Neosho (Prosser)	Greenish and chocolate shales.		11	610	
				Shaly limestones.		4	599	
			Cottonwood (Prosser)	<i>Cottonwood shales</i> ; yellowish shales, in 'the upper part unfossiliferous but containing nodules of gypsum (?); the lower part very fossiliferous.		14	595	20
			<i>Cottonwood limestone</i> ; light gray massive lime- stone containing in the upper part immense numbers of <i>Fusulina</i> .					
			Shales.					
			" <i>Dry bone limestone</i> ;" a drab to bluish silicious limestone which on weathering forms a rough surface.					
		Wabunsee (Prosser)	Shales and marls interstratified with lime- stones. Some of the limestones form thick, massive strata. In the lower part an occasional thin stratum of coal.	<i>Chonetes granulifera</i> , <i>Productus splendens</i> , <i>P. cora</i> , <i>P. nebrascen- sis</i> , <i>Spirifer planoconvexus</i> , <i>Athyris subtilita</i> , <i>Hustedtia mor- monii</i> , <i>Spirifer cameratus</i> , <i>Pinna peracuta</i> , <i>Derbya crassa</i> , <i>Meekella striato-costata</i> , <i>Spirifer- ina kentuckensis</i> .	525±	525	575±	
		Missouri (Keyes)						